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Forecasting Digital Microcircuit Obsolescence

OPERATIONS RESEARCH AND ECONOMIC ANALYSIS OFFICE

DEPARTMENT OF DEFENSE

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FOREWORD

This report documents a procedure for forecasting digital microcircuit obsolescence at the Defense Electronics Supply Center, Dayton, OH. Obsolescence is caused by rapid advancement in digital technology and decrease in commercial demand while military demand still continues. In logistics parlance, parts obsolescence is known as a Diminishing Manufacturing Source (DMS) problem. Continued supply of an obsolete DMS item is assured via substitution, alternate sourcing or a one time buy equal to the lifetime requirements of the item. Emulation is a recent alternative which explores the possibility of replacing obsolete digital microcircuits with state-of-the-art devices which can be manufactured and supplied on demand. The report recommends use of a statistical model which forecasts DMS items from a population of presently non-DMS items belonging to obsolete digital microcircuit technologies. The items forecast by the model should be evaluated for their emulation potential.

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Deputy Assistant Director
Office of Policy and Plans

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EXECUTIVE SUMMARY

Since the seventies, the Defense Electronics Supply Center (DESC) has been faced with the problem of parts obsolescence, known as the Diminishing Manufacturing Sources (DMS) problem. The problem is caused by rapid advancement in technology and a decline in commercial demand while military demand still continues. When the last component manufacturer notifies DESC that it will no longer produce the component, no alternate sources or substitutes can be found and supply requirements continue, DESC contracts with the manufacturer for a life-of-type (LOT) buy equal to the life time requirement of the item.

Several Department of Defense activities including the Defense Logistics Agency are pursuing a second alternative to managing obsolescence of digital microcircuits called emulation. Emulation explores the possibility of replacing obsolete microcircuits with state-of-the-art devices which can be manufactured and supplied on demand.

An associated problem of parts obsolescence is inadequate notice of discontinuance by the last manufacturer. This report addresses the feasibility of forecasting digital microcircuit obsolescence. If an accurate forecasting method is devised, then adequate lead time will be available to research various alternatives for future supply of parts.

The methodology and analysis in this report uses several data sources and takes advantage of the peculiar logistic characteristics of DMS items. A statistical model, employing a technique called discriminant analysis is used to select items which possess these characteristics but are not yet DMS and are therefore potential DMS items.

The report recommends use of the discriminant model as a tool to forecast potential DMS items and to provide candidate items for emulation.

I. INTRODUCTION. The Defense Manufacturing Engineering Research Office (DLA-DMERO) requested assistance from the Operations Research and Economic Analysis Office (DLA-LO) in establishing a methodology for forecasting digital microcircuit obsolescence. The latter assigned the research project to the Defense Electronics Supply Center Operations Research Office (DESC-RO).

A. Background.

Defense Electronics Supply Center (DESC) is the prime Inventory Control Point (ICP) in the Department of Defense (DoD) for managing digital microcircuits. Since the 1970s DESC has been faced with the problem of microcircuit obsolescence. The problem has come to be known as the Diminishing Manufacturing Sources (DMS) problem. Microcircuit obsolescence is caused by rapid advancement in digital microcircuit technology and a decline in commercial demand for these components. Component manufacturers discontinue production on these "obsolete" components, though military demand continues. When the last manufacturer notifies DESC that it will no longer produce the component, no alternate source or substitute item can be found, and supply requirements exist, DESC contracts with the manufacturer for a Life-of-Type LOT) buy equal to the lifetime (generally 10 years or less) requirements of the item.

Several DoD activities including DLA, Air Force, and Navy are pursuing a second alternative to managing obsolescence called microcircuit emulation. DLA is sponsoring the Microcircuit Emulation Program (MEP) and one of its initiatives, the Generalized Emulation of Microcircuits (GEM), shows promise. The GEM program developed, by SRI International and David Sarnoff Research Center, uses a BiCMOS technology to emulate a wide variety of circuit types. The Air Force is pursuing the Microelectronics Technology Support Program (MTSP) which includes next higher assembly redesign in addition to component level replacement. The purpose of MEP is to explore the possibility of replacing obsolete technology microcircuits with state-of-the-art technology devices that are transparent to system use and, if this effort is successful, to develop a manufacturing capability to provide emulated parts on demand. The MEP includes a capability to transfer a manufacturing process to a government selected location and ensure a competitive manufacturing base. The MEP is managed by DLA-DMERO within the Production Division of the Contracting Directorate (DLA-PR).

Several briefings and meetings were held at DESC in early 1990 to discuss the GEM validation phase and its introduction into normal DESC operations. These led to the identification of several tasks, one of which was the development of a model to forecast digital microcircuit obsolescence.

B. Objectives.

1. Determine digital microcircuit technologies that are commercially obsolete, but are still in military use.

2. Determine logistic characteristics of digital microcircuits belonging to obsolete technologies but which are still being manufactured (not yet a DMS item).

3. Similarly determine logistic characteristics of digital microcircuits from obsolete technologies that are no longer manufactured after a lot buy (DMS items).

4. Identify critical characteristics that distinguish DMS items from normal items (the term "normal" will be used in this report to refer to all non-DMS items).

5. Develop a discriminant model that will apply the critical characteristics to the population of all items from the obsolete technologies and identify those that have a high potential to become DMS items.

6. Test, calibrate, and validate the discriminant model.

C. Scope.

1. The study covers DESC managed digital microcircuit items from already obsolete or about to become obsolete technologies.

2. The study uses Standard Automated Materiel Management System (SAMMS) files for the period from 1 Apr 87 to 31 Mar 90 and the Defense Logistics Services Center (DLSC) Total Item Record (TIR) file as of January 1990.

II. CONCLUSION. A discriminant model has been constructed that predicts items likely to become DMS under several obsolete digital microcircuit technologies. This model has potential for use with similar technologies.

III. RECOMMENDATIONS.

It is recommended that:

o The discriminant model developed be used as a planning tool to isolate potential DMS items and prioritize them according to statistical probabilities to become DMS.

o The items isolated and prioritized by the model be evaluated for their emulation potential.

o DESC Operations research Office (DESC-RO) run the discriminant model annually beginning calendar year 1992 and provide DLA-DMERO with the list of top 100 items arranged according to their probabilities of becoming DMS.

IV. BENEFITS.

o The model is capable of isolating potential DMS items under several obsolete technologies.

o Model will provide candidates for emulation.

o Model opens door to preventive actions should the potential items become DMS. Preventive actions include:

1. Research into continuing/alternate sources.

2. Advance warning to customers against use of the items in design of new parts and/or logistics.

o Preventive actions can help reduce investments in life-of-type DMS buys.

o The discriminant model procedure can be applied to other problem areas such as nonprocurable items or items under other technologies such as Complementary-Metal Oxide-Semiconductor Logic (CMOS).

V. METHODOLOGY

A. General.

The discriminant employed is a statistical model which uses logistic characteristics to classify items belonging to distinct groups, such as DMS and normal groups. The model also computes the probability of an item belonging to any one of the groups being tested. These probabilities are useful in ranking the items under different groups. The model will be described in more detail in section VI. B.

B. Establish Data Base.

The Study used the following files:

- DLSC's Total Item Record (TIR) file.

- DESC's Supply Control Files (SCF), Standard Pricing Master File (SPMF) and TIR.

- Data sets were established for each obsolete technology with the following data fields:

DATA FIELD	DATA SOURCE
Quarterly demand units and returns	SCF
Cost, prices and units bought	SPMF
Number of procurement sources	TIR

Data was collected for the three year period from 1 Apr 87 to 31 Mar 90.

C. Compute Measures.

The data was analyzed and refined to obtain the following distinguishing characteristics/statistical measures:

- Coefficient of demand variance.
- Slope of demand regression line.
- Ratio of average to peak demand.
- Number of zero demand quarters.
- Rate of return as percent of demand.
- Age of item since DESC date of management.
- Number of sources.
- Number of representative buys.
- Coefficient of price variance.

VI. ANALYSIS

A. Obsolete Technologies.

Since the study is concerned with obsolescence among digital microcircuits, the first task of the study was to identify obsolete technologies. Obsolete technologies are defined as those technologies which are inactive in design of new parts. They are either replaced by better technologies or discontinued due to lack of commercial demand. Obsolete technologies appear in the decline or phaseout stage of the life cycle of a military product. DESC Directorate of Engineering Standardization (DESC-E) was consulted and they identified the following six digital technologies as either obsolete or nearing obsolescence:

- Resistor Transistor Logic (RTL).
- Diode Transistor Logic (DTL).
- Emitter Coupled Logic (ECL).
- Integrated Injection Logic (IIL).
- Integrated Integrated Injection Logic (IIIL).
- Transistor Transistor Logic (TTL).

An important characteristic of these technologies is that although commercial demand has all but disappeared for these items, military demand still continues since life cycle of military systems are significantly longer than commercial systems. Table 1 gives the disposition of items for DESC and other Inventory Control Points (ICPs).

Table 1

DIGITAL MICROCIRCUITS MANAGED BY DESC AND OTHER ICPs

ICP	Items Managed
DESC	23,629 (19,690)*
Other ICPs	3,557
ICP not coded on file	4,199
TOTAL	31,385

* Family heads or preferred items.

Table 2 breaks up DESC managed items under the three management types - replenishment (REP), numeric stockage objective (NSO) and nonstocked (NSTK) items. Replenishment items are stocked items with at least 3 annual demand frequencies and at least 12 annual demand units. NSO items are also stocked but their annual frequencies are less than 3 or demand units less than 12. Nonstock items are filled from individual requisitions and sent direct delivery to the requisitioner.

Table 2

DESC DIGITAL MICROCIRCUIT ITEMS
BY TECHNOLOGY AND MANAGEMENT TYPE

Technology	Management Type			
	Rep	Nso	Nstk	Total
RTL	81	73	21	175
DTL	413	303	44	760
ECL	298	610	63	971
IIL	5	14	2	21
IIIL	-	2	-	2
TTL	4,482	10,675	2,604	17,761
TOTAL	5,279	11,677	2,734	19,690

Though the technologies are obsolete, most of the items have sufficient demand to keep the manufacturer in business. Varying percentages among the items have become DMS, that is, the last manufacturer has informed DESC that it will no longer manufacture the items. Table 3 gives a breakdown of the items which are presently normal versus DMS under the three management categories - replenishment, NSO, and nonstock. Almost all of the DMS items are replenishment items. The study excluded the fourteen NSO/nonstocked items due to lack of meaningful data.

Table 3

DMS AND NORMAL ITEMS BY MANAGEMENT TYPE

Management Type	DMS	Normal	Total
Replenishment	1,666	3,613	5,279
Numeric Stockage Objective	12	11,665	11,677
Nonstock	2	2,732	2,734
TOTAL	1,680	18,010	19,690

Table 4 lists the number of items, DMS and normal, that qualify for input to the discriminant model. These are the items from the replenishment population of 5,279 (Table 2) which have at least three years of management history from 1 Apr 87 to 31 Mar 90. Items from Integrated Injection Logic (IIL) and Integrated Integrated Injection Logic (IIIL) technologies were eliminated as being too small in number to attempt discriminant analysis.

Table 4

ITEMS FOR DISCRIMINANT ANALYSIS BY TECHNOLOGY

Technology	Nr of Items		
	DMS	Normal	Percent DMS
RTL	12	35	34
DTL	69	269	12
ECL	22	182	26
TTL	703	3,278	21
TOTAL	806	3,764	21

B. Discriminant Model

The discriminant model is a statistical procedure for classifying items among distinct groups. The model is given a sample of items from the two groups of the present study - DMS and normal items under each obsolete technology. Simply put, the model examines the characteristics of the items in the sample and computes a statistical function called discriminant function and associated probabilities. The discriminant function used in this study was the generalized squared distance D^2 of each item from the two groups. The function $D^2_t(x)$ in matrix format is:

$$D^2_t(x)=(x-m_t)'S^{-1}(x-m_t)$$

t=subscript to distinguish the groups.

S=pooled covariance matrix of the groups.

x=vector of variables (characteristics) of an item.

m_t=vector of means of variables in group t.

The posterior probability of an item belonging to group t is:

$$p_t(x) = \frac{\exp(-0.5\ D^2_t(x))}{\sum_t \exp(-0.5\ D^2_t(x))}$$

An item is classified in the DMS group if setting t = DMS produces the smallest value $D^2_t(x)$ or the largest value of $p_t(x)$.

C. Results.

Table 5 shows the sample sizes and prediction accuracies of the discriminant model for DTL, ECT, RTL, and TTL technologies. The first three technologies - RTL, ECL and DTL used all the items in their samples due to small population sizes of 12, 22, and 69 respectively. A 33% sample was used in the TTL technology since smaller size samples were not able to provide acceptable levels of accuracy. The four models were able to correctly identify 83%, 82%, 77%, and 75% of the DMS items in the population.

Table 5

DISCRIMINANT MODEL ACCURACY

Technology	Sample	Population	Prediction	
		DMS	Normal	ACCURACY
RTL	12 ea	12	35	83%
ECL	22 ea	22	182	82%
DTL	69 ea	69	269	77%
TTL	235 ea	703	3,278	75%

Table 6 gives the number of potential DMS items out of the normal group.

Table 6

POTENTIAL DMS ITEMS FROM OBSOLETE TECHNOLOGIES

Technology	# Presently Normal	# Potential DMS
RTL	35	8
ECL	182	55
DTL	269	75
TTL	3,278	1,440
TOTAL	3,764	1,570

The model computes a posterior probability 0.50 or more of the potential DMS items. By arranging the items in decreasing order of their DMS probabilities, it is possible to prioritize some items viz., top 100 as more likely to become DMS than others.

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13. ABSTRACT *(Maximum 200 words)*

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